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# WATER SUPPLY OF NORTH ITALY

Basic information for occupation authorities concerned with problems of water supply.

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CONTENTS


| | Page |
|---|---|
| A. Summary | 1 |
| B. Present Water Supply Conditions | |
| 1. North Italy (except Carso and Istria) | |
| a. Regional analysis | |
| i. Overall adequacy of water supplies | 2 |
| ii. Water pollution and quality | 4 |
| iii. Wells | 5 |
| iv. Rivers and lakes | 7 |
| v. Springs | 8 |
| b. Water supply of individual cities | |
| Alessandria | 9 |
| Arco | 10 |
| Asti | 10 |
| Bologna | 11 |
| Bra | 11 |
| Brescia | 11 |
| Casale Monferrato | 12 |
| Chieri | 13 |
| Chioggia | 14 |
| Colorna | 15 |
| Cremona | 15 |
| Cuneo | 15 |
| Domodossola | 15 |
| Ferrara | 16 |
| Genova | 16 |
| Gorizia | 17 |
| La Spezia | 17 |
| Mantova | 20 |
| Milano | 20 |
| Modena | 20 |
| Mondovi | 20 |
| Parma | 21 |
| Pavia | 21 |
| Piacenza | 21 |
| Rapallo | 22 |
| Ravenna | 22 |
| Reggio Emilia | 22 |
| Rimini | 23 |
| Saluzzo | 23 |
| Savonna | 23 |
| Torino | 25 |
| Trento | 30 |
| Treviso | 31 |

| | Page |
|---|---|
| Varese | 31 |
| Venezia | 32 |
| Verona | 33 |
| 2. Carso and Istrian areas | |
| a. Regional analysis | |
| i. Overall adequacy of water supplies | 33 |
| ii. The Istrian aqueducts | 35 |
| iii. Cherso, Brioni, and Lussino Islands | 38 |
| b. Water Supply of individual cities | |
| Abbozia | 38 |
| Fiume | 38 |
| Pola | 39 |
| Trieste | 40 |
| C. Organization, Administration, and Regulation | 41 |
| D. Irrigation | |
| 1. Importance | 43 |
| 2. Regional characteristics | 44 |
| 3. Administration | 47 |
| E. Problems and Recommendations | |
| 1. Importance of the problem | 48 |
| 2. Damage to wells and pumps | 49 |
| 3. Damage to aqueducts | 50 |
| 4. Alternate sources of supply | 50 |
| Appendix 1. Principal irrigation canals of Lombardia, Piemonte, and Emilie | |
| Figures | |

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# NORTH ITALY--WATER SUPPLY

## A. Summary

North Italy has abundant water supply except in the Carso and Istrian areas. The water resources are well developed and distributed. The Carso and Istrian areas have little accessible water, due to their limestone formation. Istria is served by three highly important aqueduct systems.

Wells are the most important source of water supply, particularly in the Po Valley. Most of the major cities of North Italy depend on wells for their water, and in most instances these wells are pumped by electricity. Springs are also an important source of urban water supply, particularly on the slopes of the Alps and Apennines, and in the lower terrace areas of the northern Po Valley. For irrigation, important amounts of water are taken from rivers, springs, and wells.

Water is said to be of good quality, though hard. Rigid specifications are made in the construction of wells and their maintenance. However, the high rate of typhoid and para-typhoid in North Italy casts some doubt upon the safeness of the water.

Disruption and wrecking of water systems would cause a great deal of confusion, inconvenience, and dislocation of activities and the rebuilding of water systems should have a high priority. Due to the

abundance of water supplies in North Italy, emergency supplies are readily available and water need not be transported great distances. Portable pipe lines could be laid quickly to provide water to critical areas with a minimum of delay. The treatment of emergency water supplies may be the most pressing water supply problem confronting occupational authorities.

B. Present Water Supply Conditions in North Italy

1. North Italy (except the Carso and Istrian areas).

a. Regional analysis of rural and urban conditions.

i. Overall adequacy of water supplies. Ordinarily there is no serious problem of water supply in North Italy outside of the Carso and Istrian areas. If, however, the Germans in their retreat destroy and dislocate water supply systems as they did at Napoli (Naples), then occupational authorities will have to deal with serious problems. The principal problem would be the purification of the emergency water supplies. There are many nearby sources of water which can be utilized for emergency supplies for most of the cities of North Italy. In section (b), below, these sources will be indicated for the individual cities providing their water systems are disrupted or destroyed.

In most of North Italy there are abundant supplies of both underground and surface water. Springs, wells, and streams are utilized for domestic consumption, industrial use, and irrigation. The various sources of supply are well developed, and the water is distributed in a modern manner. Aqueducts are numerous, and some of them are among the finest in the world.

There are considerable regional differences in the abundance of water supply. The Ligurian and southeastern Po Valley have dry summers, but available sources of supply are well utilized and no serious shortages occur. In the limestone areas of the Alps (Fig. 1), surface water is scarce, but supplies are adequate for the scant population. Part of the limestone area, the plateaus of Lavarone and Folgoria, located east of Lake Garda, between the Adige and Brenta Rivers, is strategically important for control of the Adige River Valley route to the Brenner Pass. The plateaus have relatively little water, and all possible sources are indicated on detailed Italian and Austrian maps by the symbol, ♁.

Normally, the only problem confronting occupational authorities would be the frequent checking of the potability of the water supply of the various cities. There may be minor population shifts, but unless they assume major dimensions, they would not

necessarily overburden the modern water supply systems of most of the cities.

ii. Water pollution and quality. According to informants, the water of North Italy is generally both palatable and potable. All the major cities employ sand filtration, or a combination of chemical and sand filtration, in treating their water supplies. Generally, wells are both cased and covered, which reduces the danger of contamination by underground and surface waters. The sanitation officer of a province is responsible for the potability of the water in that province. It is reported that before a well can be put into operation it must meet certain requirements of construction, and that the water must be analyzed to determine its potability.

The high rate of typhoid and para-typhoid infections in North Italy, as shown by the following table, raises a question as to whether water is as potable as it is reputed to be.

Cases of typhoid and para-typhoid infections reported for the period, May 4-27, 1942

| Compartimento | Cases |
|---|---|
| Piedmonte | 162 |
| Liguria | 123 |
| Lombardia | 342 |
| Venezia-Tridentina | 38 |
| Veneto | 176 |
| Venezia Giulia e Zara | 66 |
| Emilia | 110 |

It is not suggested that water is the cause of this high rate of infections. However, the mechanical vectors of typhoid (water, dairy products, and other foods) may be contaminated by the biological vectors (human beings or flies). Since water is the most common mechanical vector of typhoid, it should be investigated.

Most of the water of North Italy is hard; the water supply of a majority of the cities has a hardness rating of over 200 p.p.m. (For the hardness rating of the water of individual cities, see Section b, below). Torino probably has the softest water of any city in North Italy: 72 p.p.m.; Modena and Bressica have the hardest: 465 and 400 p.p.m., respectively.

iii. Wells. Both artesian and ordinary wells are important sources of water supply. Wells provide water for industrial and domestic use in many cities, directly or via aqueducts; and wells supply the irrigation and domestic needs of much of the rural population. Wells are too numerous to be systematically destroyed, and even if many were to be destroyed, the remaining wells could in an emergency supply more water by increased pumping. The destruction or partial crippling of wells would affect urban centers more than rural areas, because

in many instances groups of centrally located wells are used as a source of city water supply. Electricity is the principal source of power for well pumps, particularly in areas north of the Po River. Electricity is also used to elevate the water to the reservoirs. The disruption of the electric power of a city would, therefore, in many cases leave the city without a water supply. Unless the pumps themselves were damaged, the first act in the restoration of a city's water supply would be to repair the electric power system.

The general abundance of underground water in the Po Valley and the shallow depths at which it is encountered makes the development of ordinary wells a comparatively easy task. Depths of ordinary wells in the Po Valley and the lower valley courses of its tributaries range from 10 to 40 feet. (For detailed information concerning the depth of ground water tables and capacity of wells, see C.A.D., R&A No. 1326, pp. 42-3, and ISTD/C/239.)

Artesian and ordinary wells are found in abundance in most parts of North Italy, except the mountain slopes. Ordinary wells are concentrated chiefly in the Po Valley. There are fewer such wells north of the Po River than south, due to the abundance of springs and streams in the north. South of the Po, surface supplies are less abundant, and more wells have been developed.

Artesian wells are widely distributed in North Italy, except in Liguria and the central Po Valley in the area

around Mantova (see map in ISTD/C/239, p. 128). Generally, artesian wells are over 100 meters in depth; the deepest (1198 meters) are located southwest of Reggio. The shallowest artesian wells (less than 100 meters) are found in an area west of the Tagliamento River.

A huge concentration of artesian wells is located in the Piedmonte and western Po Valley, bounded roughly by the cities of Cuneo, Torino, Novara, and Alessandria. Along the base of the Alps there are a great number of artesian wells along the approximate line of Como, Bergamo, Brescia, Vicenza, and Treviso; along the base of the Apennines a similar concentration extends along the line of Piacenza, Parma, Reggio, Modena, Bologna, and Ravenna. Artesian wells are also found in great numbers east of a line extending from Padova, Rovigo, Ferrara, and Bologna to the coast.

iv. Rivers and lakes. Rivers are an important source of water supply for the people of North Italy. Rural areas rely less than urban centers on rivers for domestic water supplies. Some cities depend on rivers for their water supply (both domestic and industrial), or as a supplementary source of supply. Water from rivers or streams is conducted many miles by aqueducts to some urban centers. Rivers are also used to supply water for many irrigation systems. In the event of widespread destruction of water systems, the numerous rivers, especially the left-bank tributaries of the Po, would

provide a copious and dependable emergency supply of water.

In sharp contrast with southern Italy, North Italy has numerous rivers, most of which are perennial. The regimes are shown in figure 2. The Po is the major river. The left-bank (northern) tributaries of the Po are Alpine-fed and perennial. Their upper portions have a maximum discharge in summer. The lower portions have maxima in spring and autumn. Many of the streams of Emilia and Marche dry up in summer, and have their greatest discharge in spring and autumn. Rivers of the Ligurian coastal area are few in number. They are very low in summer, with a maximum in winter. In scattered limestone areas in and near the southeastern base of the Alps, stream flow shows little seasonal fluctuation.

The large lakes of North Italy are located north of the Po River, particularly in the Alpine fringe (Fig. 1). If the need arises, these lakes could be used for emergency supplies.

v. Springs. Springs are a source of water supply for much of the rural population of North Italy. In addition, many springs are utilized in supplying towns and villages either directly, or via conduits or aqueducts. Most of the larger springs are found north of the Po River, where they are a major source of water for irrigation. The springs most widely used in supplying

irrigation systems are known as the "Fontanili." The "Fontanili" emerge along a line separating the higher terrace from the lower terrace (see Fig. I-2, section I). The upper terrace lies as an outwash plain in front of a broken line of moraines extending along the foot of the Alps. It is composed of permeable gravel, sand, and pebbles, and is underlain by a clayey bed. The terrace is dissected, unproductive, and scantily peopled. Near the front edge of the terrace, water gushes out in numerous springs above the clayey bed. The lower terrace, delimited by this line of springs, is composed of finer materials, and is very fertile. The springs provide an abundant source of water supply for irrigation systems on the lower terrace.

Springs are an indestructible source of water supply, though retreating forces might make the more important ones temporarily unusable through pollution.

South of the Po River, springs are smaller and fewer than in the north. In general, the Apennines are poor in springs, particularly in the Emilian portion. The Ligurian Apennines are likewise poor in springs, especially in the western section.

b. Water supply of individual cities.

Alessandria (population 79,327). Alessandria is supplied daily with 100 litres (26 gal.) of domestic water per capita by the Monferrato aqueduct (Fig. 3).

If necessary, an additional amount up to 50 litres (13 gal.) a second can be supplied.

The Monferrato aqueduct furnishes domestic water supplies to approximately 160,000 people. The various communes receiving water from the aqueduct are united in an association (Consortium), which was established in 1935. The Società Italiana di Aquedotto per Monferrato received the concession for the construction and was granted control for a period of 60 years; two-thirds of the cost was paid by the company, one-third by the state. For details concerning the aqueduct see ISTD/C/239.

The Tanaro River flows along the northern edge of Alessandria and can be used for emergency water supply.

Arco (pop. 9,442). Water supply is taken from several deep wells, by means of modern electric pumps. The water is reported to be bacteriologically pure. It is led to the city by an aqueduct.

A small stream, several mountain lakes, and nearby Lake Garda would provide excellent emergency supplies.

Asti (pop. 48,498). Asti is supplied by the Monferrato aqueduct (Fig. 3). For a detailed description of this aqueduct system see ISTD/C/239.

Asti is situated on the north bank of the Tarnaro River, and several streams flow into the Tarnaro River near the city. These rivers provide abundant sources of emergency water supply.

Bologna (pop. 269,687). The city is supplied by three aqueducts: the Setta, Borgo Panicale, and San Ruffillo. The most important of these is the Setta which, after supplying the southern provinces, provides Bologna with 21,600 cu.m. (5,702,400 gal.) daily. The three aqueducts provide the city with a total of 36,000 cu.m. (9,204,000 gal.) daily (1932), but the yield was increased to 42,200 cu.m. (11,140,800 gal.) that same year and further increases were planned. The water is hard, with a hardness rating of 200 p.p.m. For further details of the water supply of Bologna see ISTD/C/239.

Emergency supplies of water could be obtained from the Reno River, which flows through the city, and from other nearby streams.

Bra (pop. 22,309). Two artesian wells supply water throughout the year. During droughts the wells are pumped by electric motors. The water is conducted to Bra by an aqueduct.

The Stura di Lemonte River and other nearby streams provide abundant emergency supplies of water.

Brescia (pop. 127,653). The city is supplied by three aqueducts. The water is reported to be excellent but not over-abundant. In 1932, the consumption of water was 210 litres (55 gal.) daily per person. The water is extremely hard, with a hardness rating of 409 p.p.m.

i. The Mompiano aqueduct is supplied by numerous

springs located at the foot of San Giuseppe hill. Their normal discharge varies from 250 litres (66 gal.) to 500 litres (132 gal.) per second. The water is conducted to Posterla reservoir with a capacity of 6500 cu.m. (1,716,000 gal.), and then distributed to the city.

ii. The second aqueduct conveys water from Gogozzo. The aqueduct discharges 100 litres (29 gal.) a second, and the water is stored in the Castello Reservoir 10,000 cu.m. (2,640,000 gal.)capacity.

iii. The third aqueduct is supplied by three tubular wells (Pozzi di Forcadi Cane) 323 feet deep. The wells are electrically pumped and yield 115 litres (30 gal.) a second. The water is stored in the Castello Reservoir. The Posterla and Castello reservoirs are connected with one another.

Emergency supplies of water could be obtained from the numerous nearby streams.

Casale Monferrato (pop. 39,521). Water is taken from two groups of three wells each, which are located near Giarrea at the junction of the Dora Baltea and Po Rivers. The wells are 160 feet deep. Six electric centrifugal pumps pump the water to the reservoir of Verrua Savoia, which has a capacity of 2,245,510 gal. (8,500 cum.). Two steel conduits, 500 mm. (20 inches) in diameter, bring the water to two reservoirs, located at Marcorengo and Tetti Coppa, with a combined capacity of 2,113,421 gal.

(8,000 cu. m.). Water is distributed from these reservoirs by a conduit 500 mm. (20 inches) in diameter, which divides into five branch lines. The distributing system has 310 miles of pipe, varying in diameter from 50 to 155 mm. (2 to 6 inches).

Emergency supplies of water may be obtained from the Sesia and other smaller rivers which flow into the Po.

Chieri (pop. 13,558). Wells in the neighborhood of Villastella are the major source of water supply. The system consists of 4 artesian wells with depths of 100 to 220 feet. Water from the deepest well rises naturally and flows 5 liters (1.3 gal.) per sec., and 45 liters (12 gal.) per sec. is produced by pumping. This is potable water and can be used without filtration or purification, since pipes joining the wells to the decompression chamber are of unsoldered steel, preventing contamination. Conduction lines follow roads. The storage tank in the village of Villastella is on a hill 155 feet high and is completely underground. It is 65 feet in diameter, constructed of armoured cement, and has a capacity of 396,266 gal. (1500 cu. m.). A rectangular unit (manouvering chamber) is designed to accumulate water in times of low consumption, and may also give access to the tank, through a sealed door. This water system give sufficient water for the city of Chieri and neighboring communities.

The Societa Acque Potable di Torino built the plant and has control of it for 35 years, after which time it will become the property of the commune of Chieri.

In emergencies, a small river on the east side of the city can be used.

Chioggia (pop. 39,435). In 1931 the construction of a new aqueduct for Chioggia was undertaken by provincial authorities. It is not known to what extent the water system, described below, is actually in operation at present.

According to the plans, the water was to be taken from below the level of the bed of the Adige River south of town by means of 24 semi-artesian wells with a total daily yield of about 2,000,000 gal. After purification, the water is raised 246 feet through 400-mm. (15.75-inch) pipe to a reservoir of about 25,000 gal. capacity. Thence the water is conducted by gravity to reservoir tanks at Chioggia and the village of Sottomarina, just east of Chioggia. From these two tanks, with capacities of about 160,000 and 100,000 gal., respectively, the water enters the mains of the distributing systems of the towns.

The Sottomarina system was to be new construction, while the Chioggia one was merely an improvement of an existing system. Construction was to be performed by a concession company, which was to have a concession on water sales for 30 years, at the end of which time the commune will take full possession of the system.

Numerous nearby canals may be used for emergency

water supplies. Water boats are also a possible source.

Colorna (pop. 7,698). Water is obtained from a well located near the Colorna-Parma road. The well is 388 feet deep, and is cased with drawn steel tubes 7.9 inches in diameter. Water is stored in a nearby reservoir of 79,200 gal. capacity. The water is reported to be excellent, except for an excessive iron content.

Emergency supplies can be obtained from the Parma River, which flows through the town.

Cremona (pop. 64,019). The water supply of the town is obtained from numerous wells on the banks of the Po River.

The district has a network of canals and small streams from which, as well as from the Po, abundant emergency supplies can be obtained.

Cuneo (pop. 35,321). The city water supply is derived from springs near Entraque. In 1932, it was planned to increase the inadequate supply of the city by piping water from the reservoir in Regione Crocetta, capacity 6000 cu. m. (1,585,066 gal.). It is not known whether or not this plan was carried out.

In case of emergency, water can be used from the Stura di Demonte River and nearby streams.

Domodossola (pop. 10,824). The towns is supplied by 6 groups of springs. The water is conducted 1.9 miles in steel pipes to the bottom of the valley, where it is

stored in three collecting tanks. Thence it is conducted to a new reservoir and stored for distribution to the city mains.

A small stream and several mountain lakes provide emergency supplies of water.

Ferrara (pop. 119,552). The city is supplied by a new aqueduct (completed 1929). The water is obtained from electrically pumped wells located on the banks of the Po. In addition to supplying the city, the aqueduct furnishes water to 100,000 inhabitants in the surrounding area. For details concerning the aqueduct and water system see, ISTD/c/239. An old aqueduct was still in use in 1932 but no information is available concerning its use and capacity. The water of Ferrara is hard, with a hardness rating of 230 p.p.m.

A small river south of the city, and the nearby Po, can be used for emergency supplies of water.

Genova (pop. 634,646). The city is supplied by five aqueducts which are in order of age: Civico, Nicolay, Ferrari Galliera, Genovese, and Val Noci. The Civico aqueduct water is used for street cleaning and fire hydrants; that of Ferrari Galliera for industrial purposes. It is reported that the water of the Genovese aqueduct is very hard; that of the Val Noci very soft. For details of the aqueducts see, ISTD/c/239, and ISTD, Genova.

Emergency supplies could be obtained from small streams in and near the city, though the streams are probably too low to be depended upon for surface supplies

in summer, and wells might have to be sunk in the stream beds. Farther away are several small mountain lakes which might furnish emergency supplies. Water can be supplied also by water boats.

Gorizia (pop. 51,475). Wells on the left bank of the Isonzo River are the main source. The water is pumped to a reservoir at Monte Santo (792,000 gal. capacity), thence to a reservoir at Castello. Cast-iron pipes conduct the water to the city.

The Isonzo River flows through the western part of the city and can be used for an emergency supply of water.

La Spezia (pop. 106,119). La Spezzia is well-supplied with water. There are numerous springs and wells in the surrounding area, and many additional borings have been made in recent decades. Five aqueducts serve the commune, with a total daily capacity of about 25,000 cu. m. (6,600,000 gal.).

1. New communal aqueduct. The "new" (1934) communal aqueduct of Spezia is the largest of the five aqueducts. Water is obtained from 29 wells in the floor of the Magra River Valley, northeast of the city. The wells have tubular steel casing 10 to 15 cm. (4 to 6 inches) in diameter, sunk to sandstone bedrock at a depth of as much as 121 feet. There are two central pumps, one with electric motor and one with steam motor, which force the water into a gallery dug out of the mountain as a reservoir. The principal conduit, buried 6.5 feet below ground, starts at the west end of this

reservoir and conducts the water by gravity to two central cement reservoirs in La Spezia. In 1934 the gallery-reservoir had a capacity 17,000 cu. m. (4,500,000 gal.) of potable water, but with existing piping, only 12,000 cu. m. (3,170,000 gal.) per day can be conveyed to the commune of La Spezia. The water is excellent and does not need filtering or purifying.

ii. Aqueduct of the Società Generale dell'Acqua. The aqueduct of the Società Generale dell'Acqua was taken over by the commune of La Spezia in 1934. Water is obtained from small streams beyond the village of Foce, a little more than a mile northwest of La Spezia. The flow of the streams and their source springs fluctuates widely in accordance with rainfall and drought. The aqueduct has a capacity of 3000 cu. m. (about 800,000 gal.) per day.

iii. The communal aqueduct of Canneto. The communal aqueduct of Canneto utilizes the water issuing from the west branch of the Monte Biassa railroad tunnel of the La Spezia - Genova line west of La Spezia. Springs in this tunnel furnish about 35 litres (9 gal.) per second, and drought reduces the flow to 24 litres (6 gal.). The springs come from very slow infiltration, and show the effects of rainfall only after a lag of three months.

iv. Aqueduct of the Royal Navy. The aqueduct of the Royal Italian Navy for the Royal Arsenal uses the springs of the east branch of the tunnel of Biassa. With

one exception, the flow of all these springs is affected by recent rains and long droughts. The water is filtered and is purified by ozone. The average capacity is 3000 to 3500 cu. m. (800,000 to 925,000 gal.) daily.

v. Aqueduct of the Società Zona Oriental del Golfo. The aqueduct of the Società Zona Oriental del Golfo takes water from six wells, which are sunk near Ghiacciaia and driven by two centrifugal pumps with a daily capacity of 3800 cu. m. (1,000,000 gal.). The aqueduct runs to Ceresole, where it divides into two piping systems, one of which leads to the Polveriere and Cantieri Militari (powder house and military ship yard of the Royal Italian Navy), and the other to the commune of Lerici (pop. 11,318) a small fishing village four miles southeast of La Spezia. The system, which has a length of 6.2 miles, also serves private houses, fountains, and important factories.

vi. Other aqueducts. Several subsidiary lines branch from the mentioned aqueducts. In addition, there are many other small aqueducts which provide excellent water for the whole commune of La Spezia.

vii. Emergency Supplies. In case of emergency, water can be taken from many nearby mountain streams, or from the Vara River. Some of the smaller streams dry up in summer. Water can also be supplied by waterboats.

Mantova (pop. 40,467). The supply is taken from numerous wells, 300 feet in depth. For details see, ISTD/c/239.

The adjacent Mincio River can be used for emergency water supply.

Milano (pop. 1,115,848). Water is obtained from hundreds of wells in or near the city. Each well has a pump, electrically operated in most instances, forcing the water into a reinforced concrete collecting basin which acts as a reservoir, to supply the peak load requirements. More wells and pumping plants have been installed as the city has grown. The water supply is said to be bacteriologically and chemically good, though one report states that there is no purification plant. The hardness rating is 157 p.p.m.

In emergencies, water from nearby small streams can be used.

Modena (pop. 96,337). Water supply for the city is taken from wells in Lona di Cognento, about 3.5 miles from the city. In 1932, reports indicated that the water was abundant and chemically pure. Many other wells were under construction, whichwould ultimately furnish each inhabitant 120 litres a day.

The water is hard, with a hardness of 465 p.p.m.

The Secchia and Panaro Rivers are nearby and can be used for emergency supplies.

Mondovi (pop. 21,185). The city is supplied by an aqueduct fed by three springs: Dho, Ray, and Bortini.

There is a large fluctuation in the amount of water supplied. The water is stored in a half-buried concrete reservoir of sufficient size (142,560 gal. capacity) to contain the water discharged by the aqueduct in a period of 12 hours; an amount equal to the city's consumption for a like period of time.

The Tanaro River flows through the city and would provide abundant emergency supply.

Parma (pop. 75,768). Parma is supplied by two sources: the Marano springs and the Molini Bassi wells. For details of the aqueducts and pumping stations see, ISTD/c/239.

The Parma River flows through the city and could be used as an emergency source of water supply.

Pavia (pop. 51,741). The city takes water from a series of artesian wells in the environs. Well depths vary from 24 to 150 feet. The water rises naturally in some wells; in others it is pumped to the surface. Cast-iron pipes conduct the water to reservoirs. The water supply of the city is fairly hard, with a hardness rating of 166 p.p.m.

The Ticino River flows south of the city and enters the Po River only a few miles southeast of Pavia. Several other nearby streams can also be used for emergency supplies of water.

Piacenza (pop. 64,210). The water supply is taken from 300 privately-owned wells, located around the city. Water is pumped to basins and then to reservoirs.

Emergency water supply could be drawn from the Po, north of the city.

Rapallo (pop. 14,337). The entire city was originally supplied by the Aquedotto Cuneo, which is owned by a private organization. This source has been supplemented by three wells, near the officina of the aqueduct, in the valleys of the Foggia, San Pietro, and Santa Maria Rivers, yielding an abundance of pure water. There is a subsidiary pipe line on the right bank of the Boate River. Water pressure is high enough so that water can reach the roofs of all houses.

In emergencies the city could be supplied from small mountain streams which enter the Golfo di Genova nearby.

Ravenna (pop. 80,664). The water supply is taken from artesian wells at Torre Pedrera and conducted to Ravenna by aqueduct. Water is supplied to Ravenna, the dockyards, and Porto Corsini. For details of the aqueduct and water system see, ISTD/c/239. A half-buried reservoir (1,056,000 gal. capacity) is located near Ravenna and functions as a reserve in the event of a breakdown of the system.

Many streams and canals near the city could be utilized for emergency supplies of water.

Reggio Emilia (pop. 93,050). Wells located at Patri di Montecchio, Villa Colla and in an area south of the city, are the source of water supply. The water is very hard, with a hardness rating of 340 p.p.m.

Two nearby small streams could be utilized as emergency sources.

Rimini (pop. approx. 60,000). An abundant supply of pure water is available from a deep underground spring. The level of the water seems to be related to that of the Foglia River.

Several small streams enter the sea near the city and could be used for emergency water supplies.

Saluzzo (pop. 17,621). The city was formerly supplied by an aqueduct which proved inadequate (1930). New wells were constructed at Piazza d'Armi and the water conducted to the city via the existing municipal aqueduct. The wells were pumped by two groups of electro-centrifugal pumps providing 143 litres (38 gal.) daily to each inhabitant. In 1932 this system proved inadequate to meet the water requirements and troublesome landslides were occurring in the zone traversed by the aqueduct. The same year a rich water layer was found in the Valle Varaita and plans were made to construct a tubular well which, under natural pressure, would force the water to the soil level. It is believed that this well has been completed and is now serving Saluzzo.

Emergency supplies of water could be obtained a mile west of town from a small tributary of the Po River.

Savona (pop. 64,199). Water is supplied by the Savona aqueduct from a spring-fed reservoir located in the hills north of the city. The aqueduct is owned by

the Societe Acquedotte di Savonia. Water is reported to be abundant, and is supplied to all quays in the port area.

The Letimbro River flows through the center of the city and could be used in an emergency.

Torino (pop. 629,115) The water supply for the city of Torino is collected from four separate sources, within a radius of 12 miles of the center of the city, and transported by aqueducts to the city distribution system (Figure 4.)

The Torino Water Corporation (Societa Anonima per la Condotta di Acqua Portabile) owns the whole system.

1. Sources. As reported in 1928, the four collecting works and sources are as follows:

(a) The Scalonghe source is located near the village of Scalenghe, 12 miles southwest of the city, and is the most important. It consists of 180 wells, ranging from 100 to 300 feet deep, from which water is pumped into the Scalenghe aqueduct by ten electro-centrifugal pumping units at the rate of 42 cu. ft. (311 gal.) per second. The water is of excellent quality.

(b) The Val Sangone source is in the drainage area of the Sangone River at a point 9 miles west of the city. Collection is by a number of masonry-lined, subterranean infiltration galleries, having a combined length of 1.5 miles. The water is of excellent quality and flows by gravity at the rate of 16 cu. ft. (118 gal.) per second into a small underground reservoir, from which it passes, also by gravity, into the Val Sangone aqueduct.

(c) The Millefonti source is adjacent to the Po River on the southern outskirts of the city. The collection works consist of 1300 feet of subterranean, masonry-

lined infiltration galleries. The water, of rather poor quality, flows by gravity at a rate of 12 cu. ft. (88 gal.) per second into a sump well, from which it is pumped directly into the city's distribution system.

(d) The Favorita source is located in the drainage area of the Stura River, at a point 7.5 miles north of the city. The collection works consist of 1700 feet of subterranean, masonry-lined infiltration galleries, from which water of fair quality flows at the rate of 7 cu.ft. (52 gal.) per second by gravity into a pump sump. The water is pumped into a masonry reservoir from which it flows by gravity into the Favorita aqueduct.

2. Aqueducts

(a) The Scalenghe aqueduct is of reinforced concrete construction for the first 3.5 miles, from the intake chamber to the village of Volvera. This section is designed for light-pressure gravity flow. For the next 5 miles, to Bienasco reservoir, construction is of masonry and designed for free gravity flow. From the Bienasco reservoir the aqueduct joins that of Val Sangone. Through this last section, the water is pumped by the Bienasco pumping station. Nearly all the aqueduct is below ground ( Figure 4.)

(b) The Val Sangone aqueduct consists of a single, gravity-flow masonry conduit between the intake at the Val Sangone source and Regina Margherita reservoir, 6 miles distant. Three parallel cast-iron pressure conduits 11

miles long, and 1.5 miles of reinforced concrete, pressure conduit lead from this reservoir to various connections in the city's distribution system. All sections are gravity flow.

(c) The Favorita Aqueduct is made of a patented local asbestos construction (Eternit, for eight miles of its length, from the source to a point north of the Stura River. For the remaining 2.5 miles to the point where it connects with the Torino distribution system, it is of cast iron.

3. Reservoirs. There are seven reservoirs having a combined capacity of approximately 16,000,000 gal. or about 30 percent in excess of the daily demand.

Both the Val Sangone and the Favorita reservoirs are located at the source, are of masonry construction, and have a capacity 430,000 gal. each.

There are three pressure reservoirs on the Val Sangone aqueduct near the village of Regina Margherita. One is semi-obsolete, underground, of masonry construction, with a capacity of 690,000 gal.; the next, slightly less obsolete, also underground and of masonry construction, has a capacity of 2,000,000 gal.; the third, located in Regina Margherita is of modern reinforced concrete construction, with a capacity of 9,500,000 gal.

An intermediate reservoir is located on the Scalenghe aqueduct at the point where the acqueduct crosses the Sangano River near the village of Bienasco. It is underground and of modern reinforced concrete construction, with a capacity of 1,320,000 gal. It is from this reservoir that Scalenghe aqueduct water is pumped into the Val Sangone aqueduct.

The Valsalice reservoir is located on the outskirts of Torino, just east of the Po River. It is on high ground and serves as a pressure regulator for the distribution system. It is of masonry construction, underground, old, and has a capacity of 1,680,000 gal.

4. Pumping stations. The system has four pumping stations, with a combined capacity of 41,000 gal. per minute. A majority of the pumps are electrically driven.

(a) The Scalenghe pumping plant, located just to the north of the field of driven wells, has a capacity of 16,000 gal. per minute. It consists of electric centrifugal pumps with capacities of 20 to 800 gal. a minute, located in 10 masonry houses, 2 pumps to a house. The electric substation is a modern concrete structure, containing two 100-KVA and one 200-KVA transformers, stepping the 23,500 volts down to 500 volts while three motor generators change the current from A.C. to D.C. A reserve 120-KW Diesel generator existed in 1928.

(b) The Bienasco pumping station, with capacity of 13,780 gal. a minute, is immediately adjacent to the reservoir. The equipment consists of four single-stage centrifugal electrically driven pumps, two with a capacity of 4750 gal. a minute each, one 2380 gal. and one 1900 gal. A three-phase transformer reduces the current from 24,000 to 500 volts. There is a 465-KVA Diesel generator which can be used in emergency. All buildings are of reinforced concrete and of modern design.

(c) The Millefonti pumping station, located immediately adjacent to the source, has a capacity of 8000 gal. per minute. Equipment consists of: 3 Reidler-Tosi horizontal, reciprocal steam pumps, each of 1600 gal. per minute capacity; one electric centrifugal pump (multi-stage) with a capacity of 2400 gal. per minute, and one with a capacity of 800 gal. per minute. The pumping station is of obsolete masonry construction.

(d) The Favorita pumping station is located at the source and has a maximum capacity of 2850 gal. per minute. Its equipment consists of three multi-stage centrifugal pumps of equal capacity located in a sump well 90 feet underground. Two are driven by a single, high-speed, vertical, triple expansion, reciprocating steam engine, through belts and shafts. The third is driven by an A.C. electric motor directly connected to the pump by a shaft. The plant is of semi-modern masonry construction.

5. Distribution system. The distribution system with-

in the city consists of 162 miles of mains, laterals, and sublaterals, practically all of which are of medium-weight bell-and-spigot cast iron. The pipes have leaded joints, and are buried at an average depth of 5 feet.

6. Water Quality. The water supply of the city is soft, with a hardness ratio of 74 p.p.m.

7. Supplementary Sources. The Po River, which flows through the city, and the many nearby streams, would serve as excellent supplementary sources.

Trento (pop. 56,017) There are two sources of water supply for the city and commune. One, an old aqueduct, with water from seepage galleries 3 miles southeast of the city; the other, water from the Fersina River, which is transported through 360 feet of tunnel and 2700 feet of 15-inch cast-iron pressure pipe. The two storage reservoirs have a combined capacity of 500,000 gal., which is equivalent to the maximum consumption for 6 hours. The distributing system consists of 20 miles of cast-iron mains from 3 to 12 inches in diameter.

The Societa Industriale Trentina owns and operates the water supply.

In emergencies the Adige and Brenta Rivers could be used for water supply.

Treviso (pop. 53,886). The Schievenin aqueduct supplies the city of Treviso and 20 communes in the districts of Asolo, Montebelluno, Valdobbiadna, and Conegliano. The aqueduct supplies a total population of 120,000.

The water for the aqueduct is taken from two points on the Tegorso River, north of Schievenin. The aqueduct discharges 300 liters (79 Gal.) a second, and serves the more distant centers by pumping. The pipes are of cast iron and the pressure reaches 220 lbs. per sq. inch at some points. For details of the aqueduct see, ISTD/C/239.

An association was formed in 1925 to build the aqueduct. The state assumed 75 percent of the cost of the aqueduct for the rural areas.

Emergency water supplies could be obtained from a stream flowing through the city.

Varese (pop. 44,832). The province and city of Varese utilize water from the following sources: 46 springs, 46 wells, 3 filtering Galleries, and one spring well. In most instances the water is conducted by aqueducts to the populated centers. The water is raised to the aqueducts by electrically operated pumps. Storage reservoirs are constructed of reinforced concrete. Varese is supplied with 350 liters (92 Gal.) per person per day.

Several nearby lakes could be used for emergency supplies. Lake Varese is approximately 2 miles south of the city.

Venezia (pop. 264,027) Venezia is supplied with drinking water via a pipeline from Sant'Ambrogio. From the main which supplies Venezia, a branch line (with pipe 31.5 inches in diameter) runs to Porto Maghera. Good industrial water is brought from the Brenta River by a cement pipeline (47¼ inches in diameter) running along the left bank of the Junction Canal. Some additional details on the water supply of Venezia and Porto Maghera are given in Engineering Study #60, vol. II, and ISTD/C/239.

The ground water is a very few feet beneath the surface, and is salty.

At one time, Venezia had 200 public cisterns, and 1900 private cisterns, with a total capacity of 200,000 cu.m. (52,835,500 gal.), for storing rainwater. No information is available on their present use. These cisterns were dug as deep as possible in open squares and in the yards of houses. They were generally 20 feet deep (about 16 feet under the general highwater level of the lagoon). The bottom of the cisterns was covered with impervious clay. A box was placed in the center and sand poured around it in the reservoir. Surface water running into the cistern, filtered through the sand and seeped into the well-box in the center of the cistern. Filtration through sand, which was renewed from time to time, was enough to satisfy simple hygienic requirements.

Waterboats probably could provide emergency water supplies more quickly than any other means.

Verona (pop. 153,706) Water is taken from wells in the district known as "Ca' Rotta". The area is 23 feet above the Adige River and is safe from flood waters. The plant consists of three stone wells, two with a diameter of 10 feet and the other 13 feet, and a subterranean chamber. The water is pumped to a new aqueduct (completed in 1929) and delivered to Verona. The water is distributed from a reservoir of 300 cu.m. (79,200 gal.) located in the highest section of the city.

The Adige River flows through the city and several small streams are nearby, all of which could be used in an emergency.

2. Carso and Istrian areas.

a. Regional analysis of rural and urban conditions.

(1) Overall adequacy of water supplies. Both the Carso and Istrian areas have an acute problem of water supply. The Carso (karst) area lies north of a line extending between Trieste and Fiume. It has a typical karst topography with numerous sinkholes, and a dry, bare surface. The general lack of water has resulted in meager development and sparse population in the area. A description of the topography, hydrology, climate, and settlement of the Carso is given in ISTD/C/237, page

76. Istria is also composed of limestone, except for a central area of sandstone and clay (Map, ISTD/C/237, opposite page 81). The limestone portions have acute water scarcity, while the central area has a more adequate supply. A description of the relief and drainage of Istria is given in ISTD/C/237, pp. 81-3.

Springs are the best sources of water in Istria, though they are not numerous and most of them are at low elevations (slightly more than 33 feet). The spring water is conducted to the towns by aqueducts. Along the west coast, underground water is available and there are some wells. The well water is of fair quality, but during the dry season wells may produce salty water.

Before 1932, the 250,000 people of the peninsula depended chiefly upon rainwater collected in cisterns for their water supply. Today, much of the population is served by aqueducts from springs. The aqueducts were built primarily to supply the existing rural population, and to encourage people of other areas to migrate to Istria. The aqueducts supply the most densely-settled areas, in the west and northwest, and a limited area in the southeast. The rest of Istria, with a sparse population, still depends largely upon rainwater cisterns.

The destruction or crippling of the aqueducts would create a serious problem of water supply due to the lack

of alternative sources. Small reservoirs along the main distributing conduits hold the equivalent of one-third of a day's normal consumption, and these reserves, if not wrecked, would constitute a small but important emergency supply. If the pumps were destroyed, only the towns of Capodistria, Isola, Pirano, and Portorose would be supplied because this section of the Risano aqueduct is gravity-fed. The crippling of both pumps and aqueducts would necessitate the transportation of water from the aqueduct sources until the systems could be repaired.

m. The Istrian aqueducts. There are three aqueduct systems in operation in Istria today. They are in various stages of development, some portions being planned, others in process of construction, and still others in actual operation (Fig. 5). Grandiose plans were made by the Fascists, but little was accomplished, and considerable areas are still not served by aqueduct (Fig. 5).

San Giovanni aqueduct. The San Giovanni aqueduct serves an area in western Istria (Fig. 5). If developed according to plan, it will ultimately cover the entire area north of the Quieto Valley to the Dragogna Valley, and south to Dignano. The aqueduct is fed by the springs of San Giovanni, which

discharge from 200 to 2,000 liters (50 to 500 gal.) a second. Spring water is collected in a basin 72 feet in diameter, and is conducted to the treating plant. The first step in purification is mixing the water with aluminum sulphate, and then diverting it into settling basins. It is next passed through filters, and finally cleaned of bacteria by ozone. The treated water is next conducted through an asbestos-cement-coated steel pipe a distance of 11 km. (6.83 miles) to a collection basin of 2,000 cu. m. (528,555 gal.) capacity and thence to the pump station. The pump works consist of 2 centrifugal pumps delivering 25 liters (7 gal.) a second which are capable of lifting the water to a height of 340 meters (1115 ft.). The pumps are powered by electric motors (A.C.) which deliver 3,000 horsepower. Diesel-powered generators (A.C.) are a supplementary source of power, but can deliver only 1/4 to 1/3 the normal amount of water pumped. The pressure pipes are short, and they transport all the water into a collection reservoir which in turn feeds the distribution conduits by gravity. The main reservoir, at Medizzi, has a capacity of 20,000 cu.m. (5,250,000 gal.). The aqueduct delivers 100 liters (26 gal.) a second to a population of 100,000.

Risano aqueduct. The Risano aqueduct supplies the northwestern part of Istria from the Dragogna Valley to the Golfo di Trieste. The springs of Risano discharge from 0.3 to 20 cu.m. (80 to 5283 gal.) a second. The water is first conducted to a filtration plant and then through an asbestos-cement-covered steel pipe to the treating plant at Villa Decani. The water is treated in the same manner as that of the San Giovanni springs.

The towns of Capodistria, Isola, Pirano, and Portorose, in the coastal area, are gravity-fed. The other sections are supplied by small pump works. The aqueduct delivers 60 liters (16 gal.) a second to a population of 32,000.

Arsa aqueduct. The aqueduct is planned to supply the Arsa Valley in southeastern Istria (Fig. 5). The aqueduct is to be supplied by the Cossilaico, Fianona, and Gaia springs which have a minimum discharge of 8,9, and 30 liters (2,2, and 8 gal.) per second, respectively. The only section of the aqueduct completed is supplied by the Cossilaico springs, whose water requires no treatment. The Fianona spring can also be used without treatment, but the water from Gaia must be filtered and ozonized.

(111) Cherso, Brioni, and Lussino Islands. The islands of Cherso, Brioni, and Lussino, lying off the coasts of Istria, are almost waterless. Springs are lacking, but the freshwater lake, Vrena, on Cherso, is the basis of a plan to supply that island with good water (Fig. 5). Most of the islands rely chiefly on rainwater collected in cisterns for their water supply. Brioni is supplied by a submarine pipeline from Pola.

b. Water Supply of Individual Cities

Abbazia (pop. 10,032). The 1933 aqueduct, which is fed by the springs from Montemaggiore, has an insufficient supply in summer. Additional water up to 200 liters (53 gal.) per second is supplied from the Fiume aqueduct, by a conduit with a diameter of 7.9 inches. Intake pumps and meters are at Borgomarina, west of Fiume.

Fiume (pop. 53,896). Fiume has an acute problem of water supply. Potable water is supplied by waterworks, with a steam-electric plant, located on the Eneo River, about a half mile north of the beach. The city water supply has a hardness of 145 p.p.m. Water is available from hydrants to slips at wharves and by water boats to anchored ships. The Port Authority owns the water boat.

Destruction of the aqueduct would create a serious problem of water supply for the city, due to the almost waterless character of the area.

Pola (pop. 42,259). The city is supplied with water from three main reservoirs. The first reservoir is located at Monte Ghiro, about 1300 feet east of the railway station, with a pumping station about 1500 yards farther north. The second reservoir and pumping station are near Castello, adjoining and north of the post office, in the west center of town, opposite Olivi Island. The third is one mile south of Castello, at a point on Via dell Amiragliato 200 yards southeast of the junction of that road with Via M. Paradiso. Pumping stations are located about one mile north of Mt. Ghiro, east of Castello, and adjoining the amphitheatre.

Abundant water is available from the city system at hydrants located on Molo S. Tomaso, Molo Fiume, Banchina Vittorio Emanuele III, and at the wharves on the San Pietro peninsula.

Porto Brioni is supplied by a submarine water pipeline from Porto Fasana. Water is available at a hydrant on the central pier in the harbor. At Porto Fasana water is obtained from a public fountain.

Trieste (pop. 248,379). The principal supply is from the waterworks at Aurisina, seven miles west of the city. Water is obtained from springs located in a small boat-basin, beneath the waters of the Golfo di Trieste. Pumps force the water uphill to filters and a water tower (water is not chlorinated). Water is then conveyed to Trieste by two pipelines: one line runs under the Monfalcone - Trieste railroad, and uses the railroad bridges; the other runs along the hills, about 600 feet above and parallel to the railroad, and extends as far as Barcola. These pipelines discharge water into a reservoir in northern Trieste, on the heights above Gretta. Three conduits branch from the reservoir, and supply, first, the lower part of the city; second, the upper part; and third, a reservoir, near the Opicina obelisk. The pumps at Gretta supply the Opicina reservoir with water for the use of Opicina and the neighboring villages of Prosecco and Contovello in the northwest, and Trebic and Bassoviza in the southeast. Other villages are supplied by a pipeline running along the railroad from the reservoir at Oberlesetche, 14 miles east of Trieste, to Nabresina.

Water for industrial purposes is supplied by an aqueduct in the Guardiella quarter, in the eastern

part of the city. Smaller quantities are obtained from the Zaule springs (near the head of Valle di Zaule), and from neighboring wells.

The city water supply has a hardness of 172 p.p.m.

The Magazzini Generali owns and operates an extensive water supply system in the free zone, and also operates the municipally owned system at Porto Doganale. The company distributes drinking water to industrial and commercial consumers. In addition, it provides several public fountains, and water for the use of vessels at all piers and quays.

In case of emergency, several water boats owned by the Magazzini Generali could be used.

C. Organization, Administration, and Regulation of Water Supply Systems.

Most of the aqueducts and distribution systems of North Italy belong to the provinces and communes. Communes with less than 100,000 population are given state aid for the construction of water systems under a law of 1911. This enables them to contract loans with the Cassa Depositi e Prestiti for completing water supply systems. The interest rates are 2 percent for communes with more than 50,000 inhabitants, 4 percent for those with less than 50,000 inhabitants, and 2 percent with an amortization period of 35 years for communes with less than 25,000 inhabitants. Auxiliary loans amounting to not more than one fifth of the original loan

can be made for new work which had not been planned in the original project. In 1917 a law permitted the state to pay half of the 4 percent interests for communes of less than 50,000 inhabitants in which the largest community had a population of less than 30,000. In 1923 a decree authorized state subsidies execution of indispensable work, such as repairs and the for the/completion of unfinished projects.

Only four of the major aqueducts are operated by private concerns, under lease, and these will revert to the communes after the expiration of the contract period.

Water supplies in communes are inspected by the Ufficiale Sanitario who is under the podestà (mayor), and the Autorità Sanitaria. The following laws for the safeguarding of water supplies are in effect in Milano, and probably in other municipalities as well:

1. Regulations concerning wells

   (a) Permission to sink a well must be obtained from the mayor.

   (b) Wells must be not less than 30 meters (98 feet) deep, and must be more than 6 meters (20 feet) from sewage collection.

   (c) Wells must be built with metallic tube, and the tube must be connected directly to the pump.

   (d) The well must be covered.

(e) Construction of the wells must be checked by the mayor.

(f) Water must be declared drinkable by the laboratory of hygiene. If the water is unhygienic, the well must be closed immediately.

(g) If the community has no sewerage system, the mayor must determine how waste water can be disposed of to prevent contamination.

(h) Water must be checked once a year. The Ufficio Sanitario checks it at irregular intervals.

2. Regulations concerning industrial water.

(a) This type of water must be plainly indicated as being for industrial use only.

(b) There should be no taps available for public use.

3. Regulations concerning domestic construction.

(a) Pipes bringing water into the home must be of zinc-coated iron, or other metal approved by the office of hygiene.

(b) Water pipes must not be close to sewer pipes.

D. Irrigation

1. Importance of Irrigation. Irrigation is important from April to September, for crop production, in the Po Valley lowland, because of the low rainfall and high temperature of summer. In eastern Lombardia, irrigation is practiced from April 15 to September 15; in northern, southern, and western Lombardia, Piemonte and Emilia from May 1 to September 1.

Rice, a crop of major importance in North Italy, is cultivated mainly in the slightly terraced fields of the provinces of Vercelli, Novara, and Pavia (in eastern Piemonte and western Lombardia) as far south as the Po. These regions are the most highly irrigated in the entire plain. Rice fields require continuous flooding for at least three months. Rivers supply three-quarters of the water needed, and springs the other quarter.

EXTENT OF IRRIGATED AREAS

| Region | Area Cultivated (acres) | Extent of Irrigated Zone Area (acres) | Extent of Irrigated Zone Percentage | Crop most irrigated |
|---|---|---|---|---|
| 1. Lombardia | 36,077 | 11,910 | 32.9 | Rice, hay, flooded in winter, various sowings |
| 2. Piemonte | 42,996 | 11,861 | 27.7 | |
| 3. Emilia | 17,643 | 1,606 | 7.4 | |

In no other region of North Italy does percentage of cultivated land under irrigation amount to as much as 6 percent.

2. Regional characteristics. The over-all pattern of irrigation falls into the three major regions of Lombardia, Piemonte, and Emilia, by reason of the natural conditions favorable to the development of

irrigation. Figure 6 shows the areas irrigated, and the sources of irrigation water. Appendix 1 indicates the ten major canals of each region, their stream source, place of diversion, normal flow, and territory irrigated. For photographs of canals, refer to ISTD/C/237 Fig. 23.

Region 1. Lombardia has the most favorable conditions for irrigation. Water from the glacial basins, where greatest precipitation is in summer, flows into naturally regulating lakes, which supply rivers and streams with abundant water of stable volume and temperature. There are 81 canals fed by rivers.

Springs are very numerous in a zone three miles wide, extending from the Sesia River to the Oglio, along the northern edge of the Po Valley, where the notably permeable, coarser alluvial deposits are separated from the finer alluvial deposits. In the irrigated plains of Lombardia, the excavated depths for springs rarely exceed 8 to 9 feet. There are 233 canals fed by springs. Spring-fed canals are especially valuable for agriculture, because long filtration results in uniform temperature and rate of flow.

Wells are also numerous, with water obtainable at various levels between 20 meters (65 feet) and 120

meters (394 feet) below the surface. The greatest yield is from a depth of about 40 meters (131 feet). At Amontova 14 artesian wells reach depths of 120 meters (394 feet). There are about 1,000 deep wells in all.

Region 2. Piemonte is second in importance to Lombardia in irrigation. Streams flood in spring, at the time of melting Alpine snow, and with regulating lakes absent, Alpine rivers and streams are irregular and cold. There are 137 canals fed by rivers.

Springs are most abundant in the elevated province of Cuneo, also in Cavanaguolo, Racconig , and Alessandria at depths rarely exceeding 8 to 9 feet. There are 22 canals fed by springs or drainage canals.

Subterranean water occurs in important amounts only in level areas, and in valley floors bordering streams. The greatest amount occurs in the plain of Alessandria, where there are numerous wells. Wells are commonly drilled at depths of 20 meters (66 feet) and 40 meters (131 feet), with water taken at the latter level in large quantities for irrigation. Over 700 irrigation plants take water from the subsoil by electric pumps. Total yield is 12,000,000 to 32,000,000 cu.m. (3,000,000,000 to 8,500,000,000 gal.)

per year. Irrigation is greatest in the province of Vercelli.

Region 3. Emilia is least favorable of the three regions for irrigation. The period from June to August has higher temperatures and less precipitation than Lombardia or Piemonte. Irrigation is not very extensive due to the limited quantities of water available. The flow of surface water varies with precipitation and is very irregular, with high water and even floods in spring and autumn, and little or no flow in summer. However, the abundance of underground water compensates, in part, for the unfavorable climatic elements and insufficient surface water. There are 58 canals from rivers and 27 from springs or drainage systems. Wells are numerous and especially important in the province of Piacenza. Ground water occurs in large quantities between 3 and 12 meters (10-39 feet). There are also many artesian wells. In recent years, a number of wells have been added with depths of 10-14 meters (33-46 feet) and 70-150 meters (230-492 feet), irrigating 6177 acres.

3. Existing Administration. Refer to section on Hydro-Electric Power, especially under Sec. III-B 1-a, Use of Water Resources.

D. Water Supply Problems and Recommendations.

Problems arising from possible destruction of water supply systems.

1. Importance of the problem to domestic, industrial and agricultural activities. The restoration of normal water supply conditions should have high priority in rehabilitation operations. The pressing daily needs of people for water makes the problem vital, and one which should be dealt with quickly. Crippling of water supply systems causes confusion, hardships, and serious dislocation of community activities, as was demonstrated at Napoli, and disease often follows in the wake of bad water supply conditions.

The crippling of water systems seriously hampers most types of industry, particularly the heavy industries. Not only are large amounts of water needed in many industrial processes, but power also depends to a great extent upon water. If systematic destruction of Alpine hydroelectric plants or their reservoirs should occur, many industries would cease operations because most of the power used in North Italy is hydroelectric. Most city water systems, dependent upon electric pumps, would cease to operate in the event of power stoppage. Even thermal power would be

affected by reduction of water supplies, since huge volumes of suitable water are required to generate steam.

Supplying water for irrigation in North Italy is an important summer problem. Most agricultural land in North Italy does not require irrigation, but in some areas it is extremely important. Crop production would suffer in quantity and quality if facilities for distribution of water failed in summer. Plans should be made to meet the summer needs, particularly, in the ricefields. The most vulnerable parts of an irrigation system are the distribution canals and the electric pumps of the wells, rather than the sources of water. Canals can usually be easily repaired, and areas served by gravity from springs or rivers are therefore not highly vulnerable. Damage to pumps or power sources can not be so easily remedied, and might result in reduction of production.

2, Damage to wells and pumps. A majority of the city systems and irrigation systems are fed by wells pumped by electricity. The disruption of the wells, pumps, or electric power systems would seriously reduce water supplies. Pumps and wells are vulnerable to many types of damage. Damage to metal well casings

might necessitate the drilling of new wells. Damage to the electric motors and pumps would probably require long periods of time for repair. During the period required for repair or replacement, emergency supplies would be necessary. Ultimately, occupational authorities would have to import well casing, electric motors, pumps, and repair materials, because local supplies would not be sufficient to cope with a situation involving widespread wreckage. Extensive reconstruction will probably be impossible without the use of credit furnished by the United Nations.

3. Damage to aqueducts. In most cities of North Italy, water is brought from the source by aqueducts. Aqueducts are very vulnerable and in all probability key points in aqueduct systems will be blasted. The source portions of aqueducts will probably be given special attention by the Germans, to render the entire aqueduct system waterless. Damage to the aqueducts can probably be repaired quickly with local materials and local labor. Most aqueducts are constructed of stone, cement or brick, or a combination of these materials, though some are of iron pipe.

4. Alternate sources of supply. In event of a wrecked water system, an available source of

emergency supply is extremely important until the original source can be restored.

The first consideration of all water supply problems is the quantity of water available. In North Italy, except in the Carso and Istrian areas, there are abundant resources of water suitable for emergency use. A river flows through, or is located near almost every major city in North Italy. Emergency supplies will in most instances need to be transported only a short distance. This in many instances can be accomplished by the type of portable pipeline which was used with great success in North Africa. The pipe is of flexible steel and can be laid on the surface of the ground. It can be laid at the rate of 10 to 30 miles per day, and can deliver 252,000 gal. of water daily, pumped by a portable gasoline-powered pump. Motorized water tanks or water boats may also be used in transporting water.

The chlorination or other purification of all emergency water supplies will of course be essential.

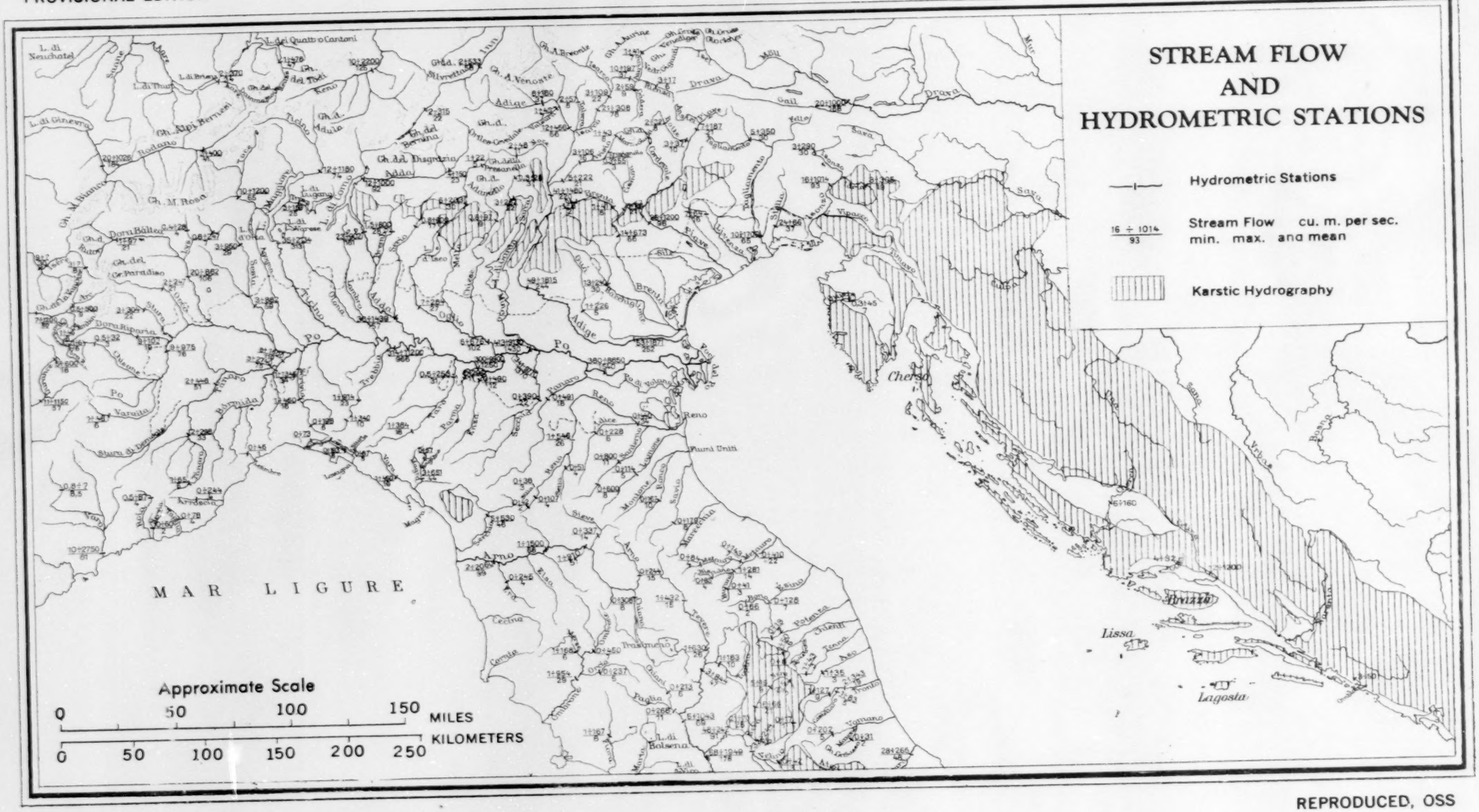
APPENDIX 1. PRINCIPAL IRRIGATION CANALS OF LOMBARDIA, PIEMONTE, AND EMILIE.

| Name of canal | Source stream and place of diversion | Normal flow (cu. m. per sec.) | Territory irrigated (acres) |
|---|---|---|---|
| **Lombardia:** | | | |
| Naviglio grande Bresciano | Chiese (Gavardo) | 12 | 18,631 |
| Naviglio vecchio et Naviglio nuovo Pallavicino | Oglio (Bombardone et Pumenengo) | 18 | 29,652 |
| Seriola Vetra | Oglio (Caeriolo) | 9.4 | 16,679 |
| Canal Marzano-Vacchelli | Adda (Bisnate) | 25 | 86,486 |
| Naviglio de la Martesana | Adda (Trezzo) | 46 | 34,594 |
| Canal de la Muzza | Adda (Cassano) | 75 | 135,907 |
| Canal Villoresi | Ticino (Panperduto) | 20 - 70 | 135,907 |
| Naviglio grande | Ticino (Tornavento) | 64 | 135,907 |
| Naviglio Langosco | Ticino (Cameri) | 18 - 52.5 | 49,420 |
| Naviglio Sforzesco | Ticino (Momentino) | 12 - 14 | 34,594 |
| **Piemonte:** | | | |
| Roggia Mora | Sesia (Prato) | 8 - 10 | 18,532 |
| Roggione di Sartirana | Sesia (Palestro) | 25 | 37,065 |
| Roggia Marchionale di Gattinara | Sesia (Gattinara) | 5 - 7 | 12,355 |
| Canal de Caluso | Orco (Spineto) | 4 - 9.5 | 21,003 |
| Canal Cavour | Po (Chivasso) | 100 - 110 | 380,540 |
| Canal Lanza | Po (Casale Monferrato) | 12 - 14 | 22,239 |
| Canal de Bene et Canal de Cherasco | Stura di Demonte | 3 - 4.6 | 23,104 |
| Canal Brobbio-Pesio | Lac de Beinette | 2.2 - 3 | 12,602 |
| Canal Vermenagna | Gesso (Boves) | 1.2 - 4.5 | 10,872 |
| Bedale del Corso | Varaita (Piasco) | 1.950 | 13,961 |
| **Emilie:** | | | |
| Riviere commune de gauche | Trebbia (Rivalta) | 1.1 | 1,546 |
| Riviere commune de droite | Trebbia Mirafiore | 2.9 | 4,181 |
| Naviglio Taro | Taro (Collecchio) | 0.5 - 1 | 1,400 |
| Canaux San Michele, Commune et Maggiore | Parme (Lesignanao) | 1 - 4 | 3,500 |
| Canal Naviglio | Parme (Parme) | 0.5 - 1 | 1,200 |
| Canal Ducale d' Enza | Enza (Ciano) | 0.8 - 1.8 | 2,000 |
| Canal de Secchia | Secchia (Castellarano) | 0.9 - 3 | 3,500 |
| Canal Maestro | Secchia (Sassuolo) | 1.4 - 4.3 | 2,300 |
| Canal de San Pietro | Panaro (Vignola) | 2.7 | 1,130 |
| Canal Torbido | Panaro (Savignano) | 0.7 - 1.1 | 1,000 |

PROVISIONAL EDITION

# NORTHERN ITALY

FREE




MAP NO. 2865
24 NOVEMBER 1943

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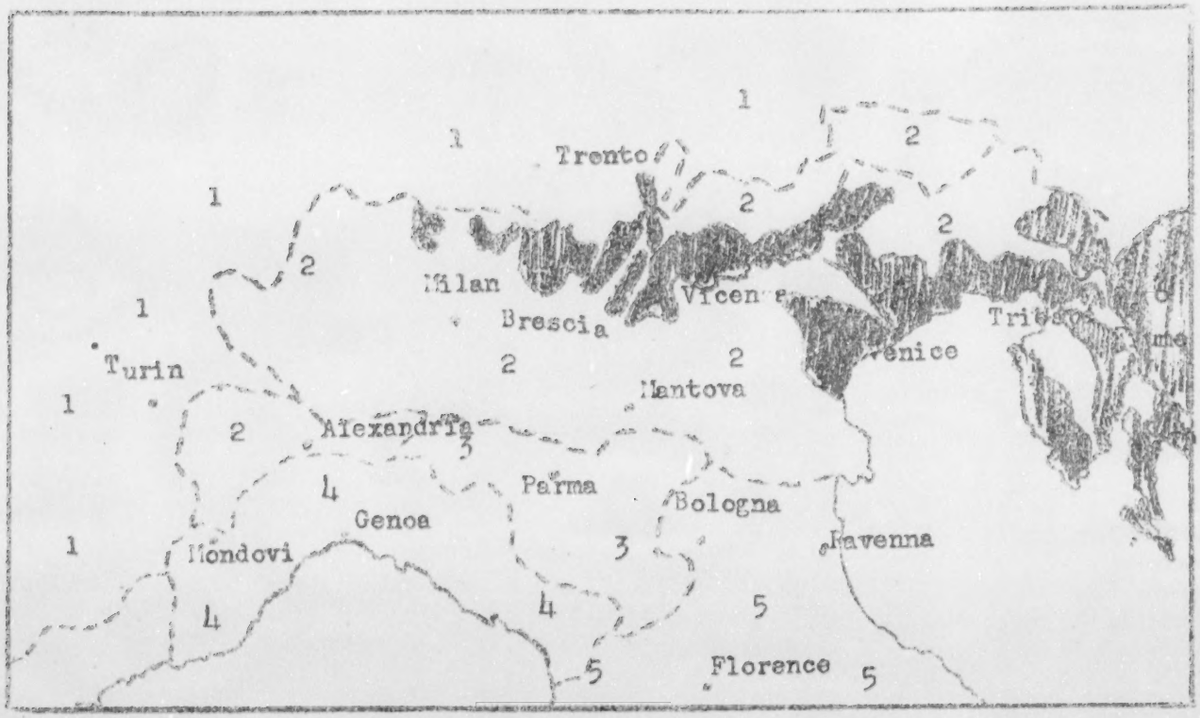
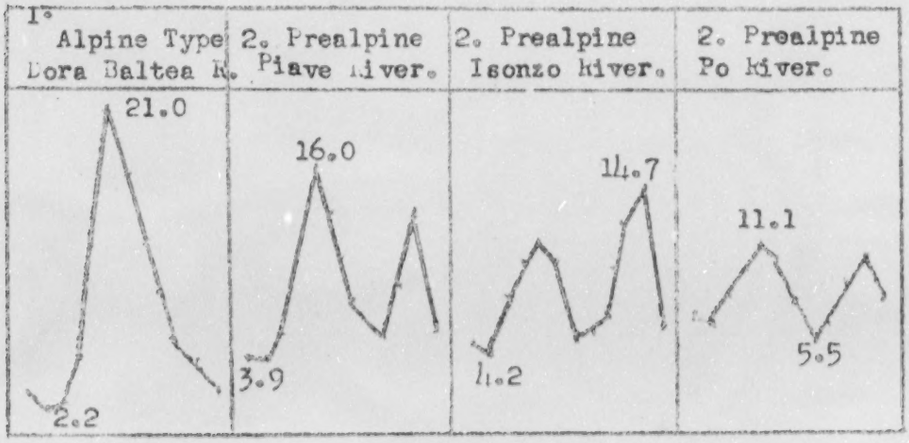
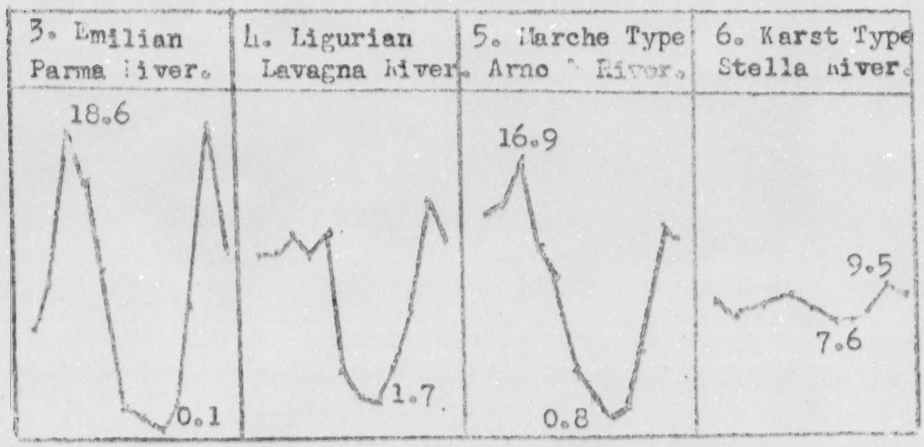
FIGURE II-1A. NORTH ITALY LOCATION MAP

FIGURE II-1A. NORTH ITALY LOCATION MAP

Fig. II-2 Principal Types of Stream Regime.




Legend

1. Alpine Type: summer max; winter min.
2. Prealpine Type: double max. (abundant water all seasons)
3. Emilian Type: double max. ( very low, late summer)
4. Ligurian Type: Nov. to May max; summer min.
5. Marche Type : spring max. (very low summer)
6. Karst Type: (little seasonal fluctuation)

Figures on graphs indicate percent of total annual flow occurring in months of maximum and minimum flow.

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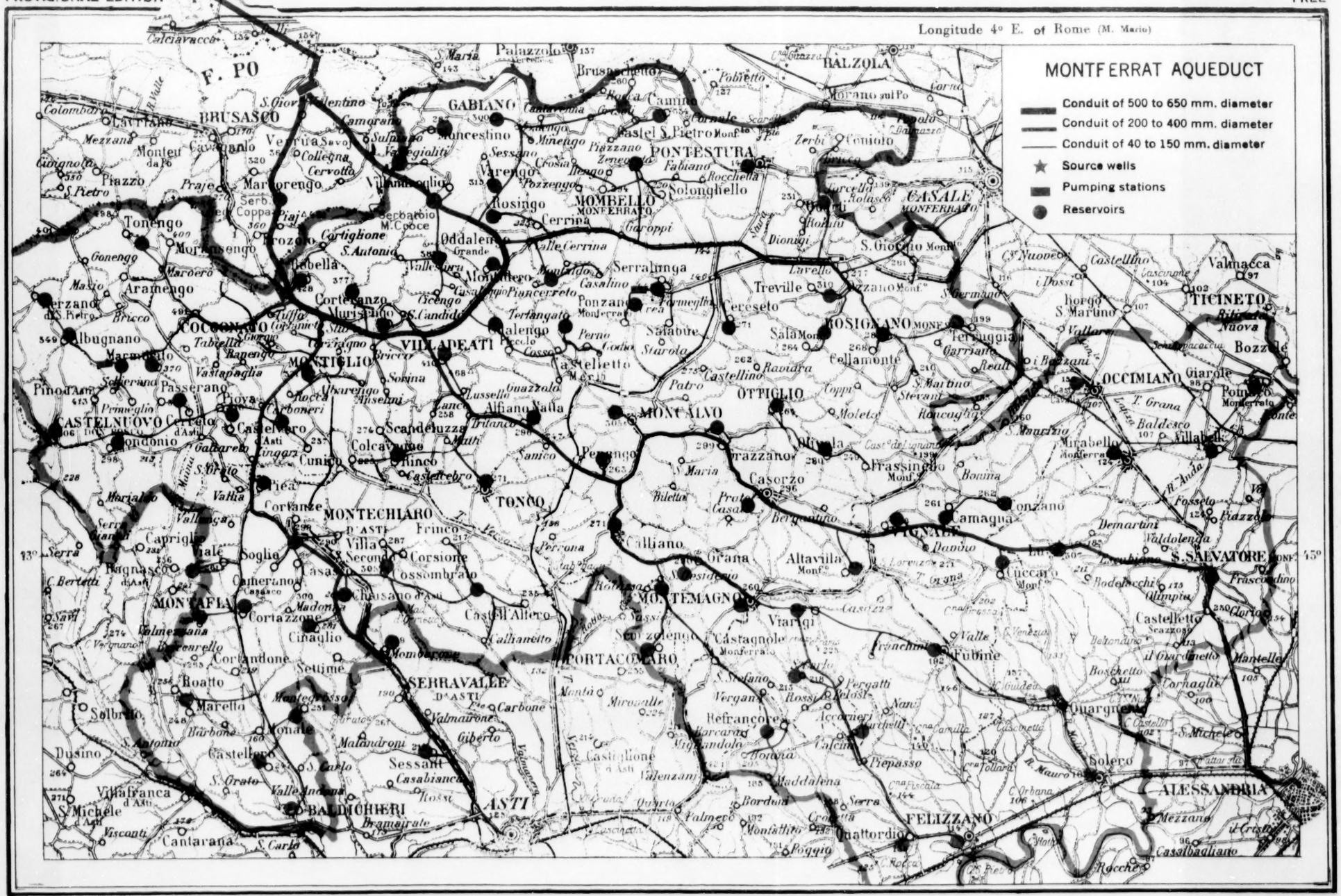


MAP NO. 2852
24 NOVEMBER 1943

Échelle de 1 : 200.000

Kilomètres

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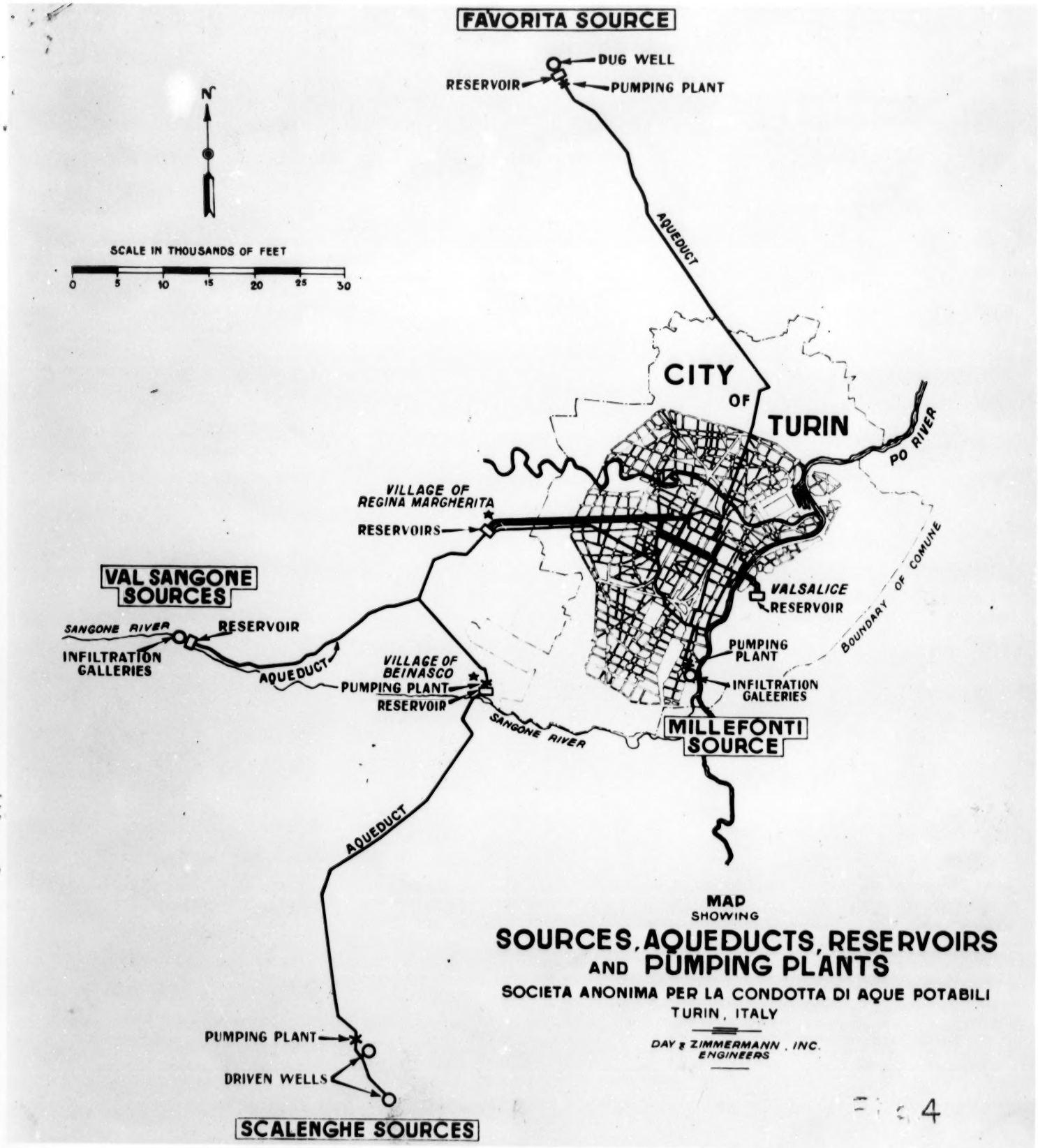


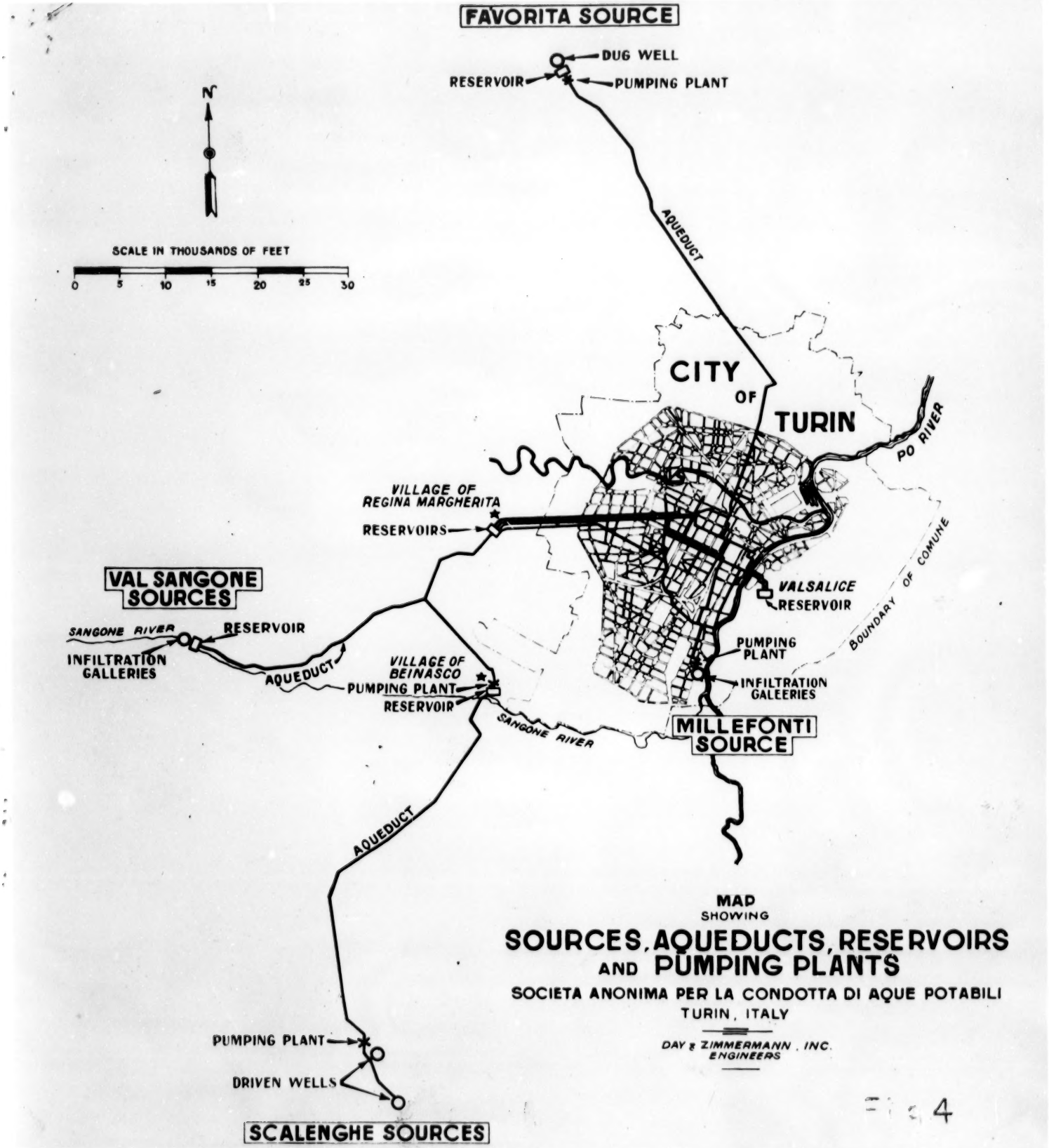

MAP
SHOWING

# SOURCES, AQUEDUCTS, RESERVOIRS AND PUMPING PLANTS

SOCIETA ANONIMA PER LA CONDOTTA DI AQUE POTABILI
TURIN, ITALY

DAY & ZIMMERMANN, INC.
ENGINEERS

Fig 4




MAP
SHOWING

# SOURCES, AQUEDUCTS, RESERVOIRS AND PUMPING PLANTS

SOCIETA ANONIMA PER LA CONDOTTA DI AQUE POTABILI
TURIN, ITALY

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Fig. 4

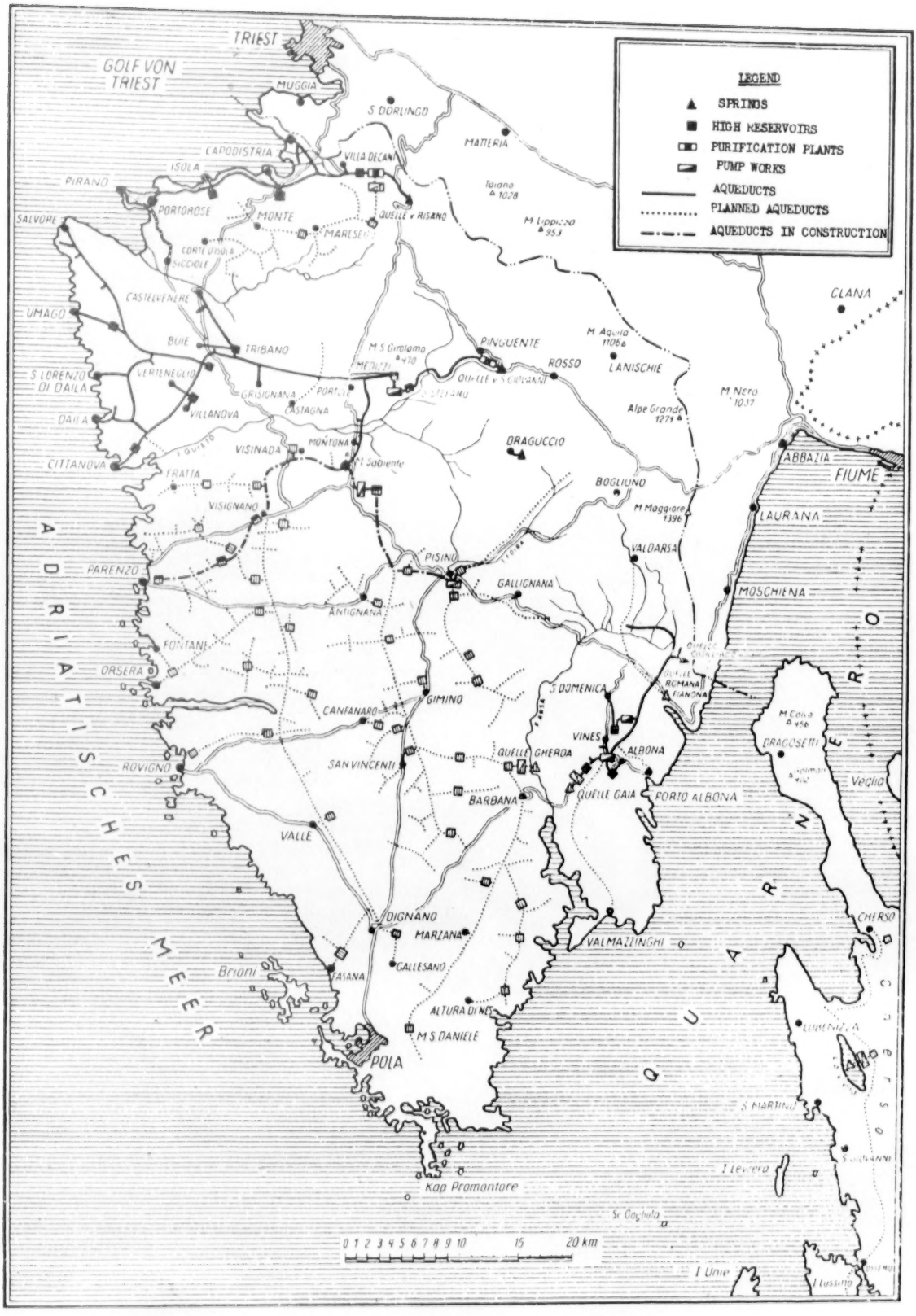


Fig. II-5. Istrian Aqueduct Systems